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PLANNING FOR NATURAL DISASTERS:

A CASE STUDY IN NORHTERN UTAH

by

Brent A. Feldt

A major paper submitted in partial fulfillment
of the requirements for the degree

of

Master of Natural Resources

in the

Department of Environment and Society
College of Natural Resources

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2003

CONTENTS

ABSTRACT

PLANNING FOR NATURAL DISASTERS:

A CASE STUDY IN NORHTERN UTAH

by

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Utah State University, 2003

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During the last two decades Utah's Mountainland Association of Govererments (MAG) region has seen rapid growth and development. Maintenance of public health, welfare, and safety has become a priority for local and county governments. The purpose of this study was to develop criteria for and locate landscape features that could affect human health or valuable structures. The model created seeks to maximize human health by giving planners information on which areas may harm water quality and quantity, may cause structural damage, and may pose a threat to safety. The landscape features included in the model are: avalanche and steep slopes, earthquake fault lines, mudslide areas, shallow groundwater, high shrink and swell soils, floodplains, and areas with high wildfire danger. The MAG region is an area that represents other rapidly growing areas of the county. While it may not have the same natural hazards as other areas, the public health, welfare, and safety model presented could easily be used in other areas where planners want to emphasize natural disaster mitigation.

(36 pages)

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

PLANNING FOR NATURAL DISASTERS: A CASE STUDY IN NORTHERN UTAH

INTRODUCTION

During the last two decades Utah's Wasatch Front has seen rapid growth and development. This growth may threaten the quality of life for many residents. Protection of surface and subsurface water sources and the maintenance of public health, welfare, and safety have become priorities for local county governments. Since most of the land being developed is privately owned, it is susceptible to many development pressures. At the same time development increases on this landscape, the threat of natural disasters also increases. The purpose of this study was to develop criteria for and locate landscape features that could affect human health or valuable structures and provide that information to planners, assisting them as they make intelligent decisions regarding development on this landscape.

The county and local governments in the study area are supported by a group that deals with region-wide issues. This group is known as the Mountainland Association of Governments (MAG). The jurisdiction of MAG includes the counties of Summit, Wasatch, and Utah (see Figure 1). The population of 300,000 residents is expected to double in 30 years, indicating a growth rate of 10,000 people annually. This will place more pressure on current development and existing open space.

Despite our increased knowledge of and ability to predict many natural disasters, governments, developers, and planners continue to construct new residential and industrial areas in places where these disasters are likely to happen. Much of the open space not currently developed in the MAG region lies in areas that are potentially

hazardous to life and property, a situation not unique to Utah (Comerio, 1998; Steinberg, 2000). For this reason, the objective of this study was to identify potentially hazardous landscape features. This information will help planners know where the most dangerous areas are located, and should be helpful in protecting the residents of the MAG region from the effects of the disasters and help governments avoid liability for allowing development in inappropriate areas. We know where disasters have occurred before and can often predict where they are most likely to occur again. It is essential that we use this knowledge when planning to make communities less vulnerable to locations which are hazardous to society (Olshansky, 2002). Planning for disasters will ultimately help everyone by saving lives, property, and federal relief funds (Godschalk et al., 1999).

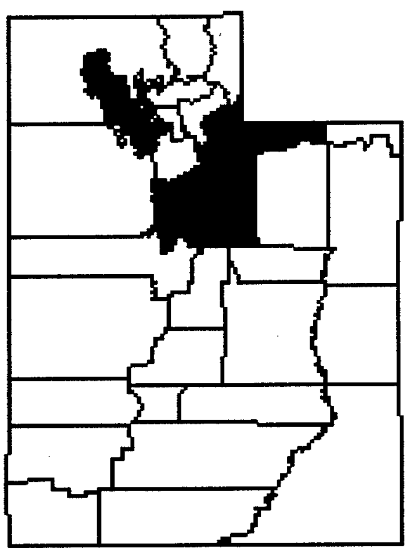

Figure 1. The location of MAG Counties in northern Utah. Utah County (blue), Wasatch County (green) and Summit County (red) have a current population of about 300,000. Utah County is the most densely populated.

NEED FOR THE STUDY

The need to give planners accurate information on threats to public health, welfare and safety has never been greater. Natural disasters are low-probability events, and building construction quality in the United States is among the best in the world. Still, despite their low-probability of affecting any one area, natural disaster occurrences are on the rise in the United States (Comerio, 1998). They cause billions of dollars in damage each year (Berke, 1998). In a five-year period from 1989-1994, more than $75 billion federal dollars were spent assisting only five communities in their disaster recovery efforts (Comerio, 1998).

The federal government has increased its emphasis on requiring communities to produce disaster mitigation plans (Burby, 1998; Godschalk et al., 1999). The Disaster Mitigation Act of 2000 created new emphasis on community-based hazard mitigation plans (Olshansky, 2002). This new emphasis has helped many communities receive government funding quickly following a disaster. Before this Act, some communities would have to wait up to two years before federal funds were made available to them.

The MAG region contains many areas that pose a hazard to public health, welfare, and safety. A major fault line runs almost directly under the area of highest population density, and shallow ground water poses a serious threat to water quality. In just the past year, the region has been the site of numerous natural disasters. A 2002 mudslide in the town of Santaquin caused the evacuation of almost 50 homes (Canham, 2002). Small earthquakes happen almost daily in the region (University of Utah Seismograph Stations, 1996). The danger of fatal avalanches rises every winter as the amount of backcountry

use by snowmobilers and skiers increases (USFS, 2002). After five years of drought in the region, the chance of deadly wildfires occurring is much higher.

The safety issues associated with these phenomena are complex, especially when viewed in light of a steadily increasing population, limited water supply, and additional pressure on infrastructure and emergency response agencies. Planners need to be aware of the likelihood of natural disasters occurring in their areas and take all precautions to prevent loss of life or property if and when these disasters happen.

STUDY METHODS

Many of these disasters are difficult if not impossible to predict. By using the best data available it is possible, however, to determine where on the landscape they are most likely to occur. Using geographic information system data (GIS), we set out to identify those areas of the MAG region that are prone to natural disasters.

The study occurred from August 2002 through April 2003, and considered incident evaluations for avalanches, earthquakes, mudslides, floods, and fires. In addition, we examined other features of the landscape that pose danger to the public, to critical infrastructures, and to residential, commercial, and institutional structures. This included soils with high shrink/swell capacity and areas with shallow ground water.

For the study, we described criteria for each landscape feature. The landscape features included did not represent all aspects of the landscape that can affect public health, welfare, and safety. The features chosen represented features that are of importance when deciding where to develop. The information presented is not a complete picture of the threat to public health, welfare, and safety in the region. We do not want to minimize

risk perception, which is possible since our data do not include an exhaustive integration of hazardous landscape features (Monmonier, 1997).

PLANNING FOR PUBLIC HEALTH WELFARE AND SAFETY

Landscapes that have the potential to negatively affect the health, welfare, and safety of the people living in the MAG region were examined. The model seeks to maximize human health by giving planners information on which areas may harm water quality and quantity, may cause structural damage, and may pose a threat to safety. Those areas not suitable for human development present excellent opportunities for open space preservation.

The MAG region lies within the Southern Rocky Mountain Steppe-Open Woodland-Coniferous Forest-Alpine Meadow and the Intermountain Semidesert and Desert ecoregions (Bailey, 1995). Because of the two distinct ecoregions that are present in the study area, there are a number of different landscape features that were included in the model. The features included are: avalanche and steep slopes, earthquake fault lines, mudslide areas, shallow groundwater, high shrink and swell soils, floodplains, and areas with high wildfire danger.

Each of the features had unique criteria that determined their location on the landscape. When examined separately, the areas all represent places that could pose a substantial threat to human health, welfare, and safety. Examined together, the areas show where human development should be avoided in the MAG region.

A matrix was developed by Toth et al. (2002) in their analysis of a five-county area along the Wasatch Front in Utah. The matrix below (see Table 1) was adapted from their study to show planners which areas have the potential to affect different aspects of public

health, welfare and safety. This matrix provides the basis of the discussion of the different landscape features that could potentially affect public health, welfare, and safety. Each of the features were examined separately and then combined into a final map showing the areas that pose the largest threat. This will help planners mitigate the negative effects of these potentially damaging landscape features.

	Landscape Features						
Affected Resources	Avalanche/ Steep Slope	Fault Lines	Mud-slides	Shrink/ Swell Soils	Shallow Ground Water	Flood-plains	High Fire Risk
Groundwater Recharge					X		
Water Quality			X		X		X
Water Quantity					X		
Human Health	X	X	X		X	X	X
Structural/ Infrastructure Damage	X	X	X	X	X	X	X
Health Care/Insurance Costs	X	X	X			X	X

Table 1. Matrix describing natural hazard landscape features and resulting impact on human health, safety, and welfare. Adapted from Toth et al. (2002).

It should be emphasized that this model does not include all potential natural hazards in the MAG region. There are other landscape features that potentially can affect resources that humans need to survive, such as liquefaction soils, volcanoes, and dust storms. The landscape features included represent those that have affected public health, welfare, and safety in the past. The likelihood of some of these landscape features affecting resources again is higher than for others.

Avalanche/Steep Slope

The Wasatch Mountains in the MAG region receive high annual snowfall. Some locales receive more than 8 meters of snow during the winter months (Worldweb Travel Guide, 2002). This snowfall gives an increasing number of backcountry recreationists excellent opportunities to ski, snowboard, and snowmobile. Unfortunately, when the snow becomes unstable on a mountainside, it can slough off and cause avalanches. These avalanches have the ability to affect human health, cause structural damage, and increase healthcare and insurance costs. This portion of the model was designed to identify those areas of the landscape that are more prone to avalanches and/or have slope characteristics that are detrimental to public well-being.

Figure 2. Skier on 38° slope. These slopes are particularly prone to avalanches. Photo by C. Gardner.

There are four characteristics that must be in place for an avalanche to occur: (1) accumulation of a "critical mass" of snow, (2) structural changes within the snow that affect the snow's stability, (3) slope angle that permits flow, and (4) a trigger (Ebert, 1988). The mechanism of an avalanche is simple. When the snow falls, it forms layers

on the ground. These layers are often different from each other, and have distinct characteristics. Some layers are stable because they are made of small, tightly-packed snowflakes. Others are more loosely-packed. If this layering effect occurs on a slope of 30 to 45 degrees, and if loose layers are covered by heavier snow, it is possible for the bottom layer to give way and cause an avalanche (Tremper, 2001). Besides the possibility of an avalanche, there are some areas that are too steep for snow to accumulate in deep layers, but are still not desirable for human habitation or development. Based on the criteria for avalanche development, we included areas of the landscape that had slope angles greater than 30 degrees (see Figure 4). This would then include both avalanche prone areas and areas with steep slope.

One of the ways avalanches and steep slopes affect the public is the danger posed to human health. In 2002, three people were killed by avalanches in Utah (USFS, 2002). Each year, many more people are partially or completely buried by avalanches and receive various injuries as a result (see Figure 3). Steep slopes pose hazards through falling off cliffs. All Utah ski resorts have an active avalanche patrol and are constantly on the lookout for avalanche conditions. Often these patrols will trigger avalanches before they become too dangerous. Also, many backcountry recreationists wear locating beacons, and avalanche education, prediction, and mitigation are on the rise, but avalanches still pose a great threat to human health.

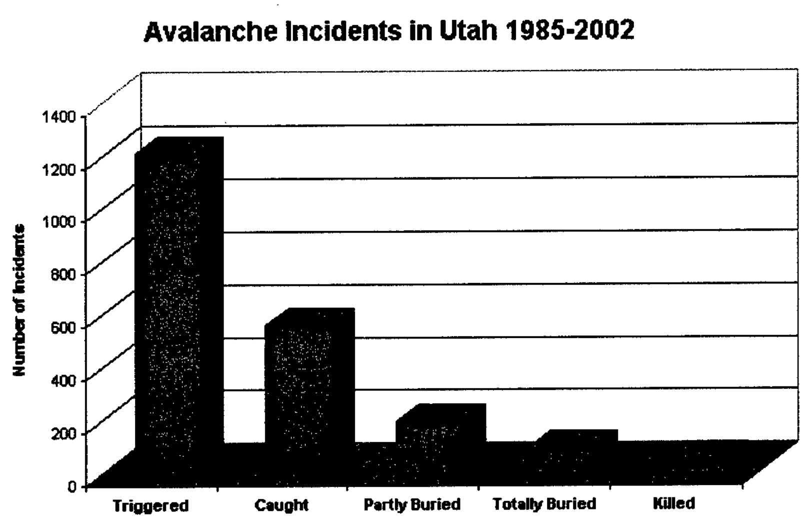

Figure 3. Avalanche incidents in Utah and their resulting impact on human health from 1985-2002 (USFS, 2002).

Avalanches also have the ability to affect infrastructure and/or residential areas. Highways and railroads that lie in avalanche paths could be blocked or destroyed by a large avalanche. In the MAG region, where there is often only one major road connecting a community to the outside world, if a road was blocked for an extended period, relief efforts could be extremely costly. Also, homes and other structures that lie in avalanche paths are susceptible to damage. Restricting or reducing development in these areas would greatly reduce the costs incurred if an avalanche occurs.

Health insurance and medical costs are also affected by avalanches. The bills associated with hospital stays greatly affect individuals and society. The rescue personnel who are sent to save avalanche victims are often volunteers or public employees who work for public agencies. Rescue work is often extremely expensive and life-threatening.

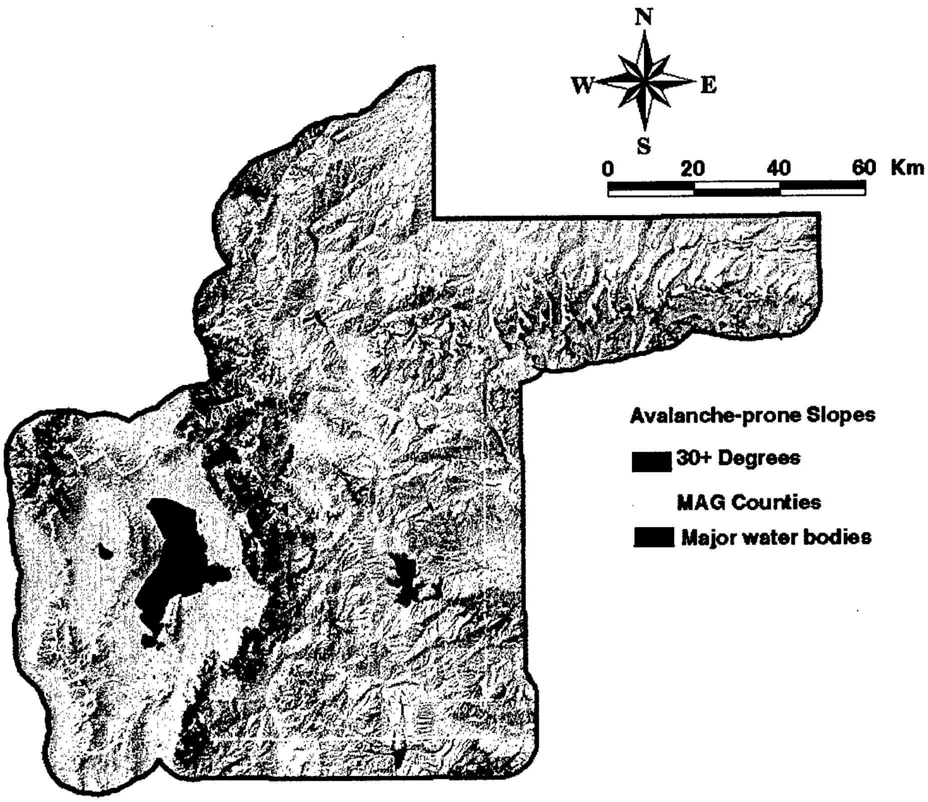

Figure 4. Potential avalanche areas and slope >30° (in red).

Fault Lines

Californians are not the only people who should worry about earthquakes. The western third of the United States is a "geologic crazy quilt" of moving plates and potential earthquakes (Harris, 1990). Utah's Wasatch Front, where the population of the study area is most concentrated, lies along an active fault system. Deep underground, the earth's geologic plates slowly move the Wasatch Mountains to the west (Morisawa, 1972). As these plates stretch along the normal fault type (Ebert, 1988), the reduced stress on the rocks pushes the mountains higher, until there comes the 2,500 to 4,000 meter peaks we see today (Morisawa, 1972). If this motion occurs slowly, it is called

creep and is often imperceptible. If it occurs quickly, then earthquakes often result (Morisawa, 1972).

While large-scale earthquakes have not occurred on the Wasatch Fault in the last three centuries, there is evidence that the fault is still active, that it has been active within the last few thousand years, and that large earthquakes should be expected in the future (Morisawa, 1972). More than 600 earthquakes occur in Utah every year. Approximately 2% of the earthquakes are felt. An average of about 13 earthquakes of magnitude 3.0 on the Richter Scale or larger occur in the region every year (University of Utah Seismograph Stations, 1996). Most often, these earthquakes happen on the faults that run under the western edge of the Wasatch Mountains. According to the University of Utah Seismograph Stations web page, the Wasatch fault is overdue for a magnitude 7-7.5 earthquake. If this happens, the earthquake could break segments of the fault about 40-80 kilometers long and produce displacements at the surface of up to 3-7 meters (University of Utah Seismograph Stations, 1996).

Of all natural disasters that affect public health, welfare, and safety, earthquakes send out the "largest and longest range of associated phenomena" that can be used to "foreshadow the impending catastrophe" (Bryant, 1991). Still, predicting an earthquake's exact timing and location is nearly impossible (Eubank, 1996; Ebert, 1988). In fact, it is often the "post-quake hazards" that cause the greatest damage (Ebert, 1988); if development is present along active fault lines, the potential for harming people and structures is high. Reducing development along the fault lines is an effective way of mitigating potential damage done by earthquakes (Steinberg, 2000). The purpose of this part of the model was to identify fault lines and include a one kilometer buffer around them. This buffer

was based on professional judgment, and could be increased or decreased, depending upon local seismic conditions, building codes, and future occurrences of earthquakes (see Figure 5).

Human health, medical costs, and structural and infrastructure integrity are all negatively affected by earthquakes. Between 1850 and 1995, earthquakes of magnitude 5.5 or greater occurred in Utah 16 times. Earthquakes this large are likely to cause surface rupture and damage homes, work places, and highways. Health insurance and medical costs will almost certainly increase in an area following an earthquake. The relief and emergency personnel and equipment needed to repair the area would be expensive. Extensive damage to structures, especially schools, hospitals, apartment buildings and other large structures can also occur during and after earthquakes. For example, in 1992 in St. George Utah, a magnitude 5.8 earthquake did little structural damage, but still did almost $1.5 million in damage (University of Utah Seismograph Stations, 1996).

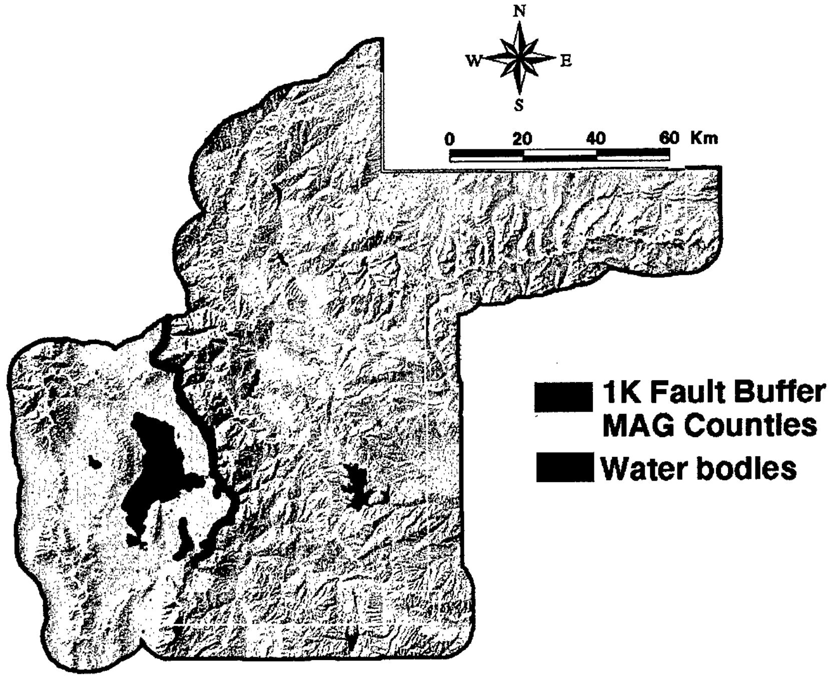

Figure 5. Fault lines in the study area (shown in red) with a 1 kilometer buffer. Some fault lines are present under Utah Lake, the large water body to the west of the major fault line, but are not visible in the figure.

Mudslides

Although mudslides are not historically recognized as causing as large a death toll as earthquakes, the damage to property is just as extensive. In fact, the loss of life associated with some earthquakes is due to mudslides that occur after the earthquake (Bryant, 1991). A mudslide is "a massive failure within a large body of earth materials" (Ebert, 1988). Mudslides occur because the shear strength of the soil or rock is not sufficient enough to resist the pull of gravity (Bryant, 1991). When soil and rock are not covered by vegetation, the shear strength of the materials is greatly reduced (Ebert, 1988).

Due to high levels of wildfires in recent years, some of the vegetative cover present in and around the mountains of the Wasatch Front has been reduced. This has increased the amount of erosion that takes place on the slopes of the mountains. When the rain falls heavily on these landscapes, mudslides can occur (Chapman, 1994).

While mudslides are a normal part of nature, catastrophic consequences can result when people's homes or other structures are in the slide path. This was observed in Santaquin and Spring Lake, Utah, in September 2002 when more than 40 homes were damaged (Canham, 2002). In 1992 in Springdale Utah, a mudslide destroyed two water tanks, several storage buildings, three homes in a subdivision, blocked State Route 9, and ruptured utility lines (see Figure 6) (University of Utah Seismograph Stations, 1996). The purpose of this part of the model was to identify locations that are known or potential mudslide locations (see Figure 7).

Figure 6. A landslide in 1992 toppled telephone poles and blocked State Route 9 outside Springdale, Utah.

Mudslides have the potential to negatively affect human health, cause structural damage, and increase medical insurance and health care costs. When mudslides affect residential

or commercial areas, people are often caught in the slides. Homes and other structures are damaged by the weight and speed of the moving earth. Power lines can be knocked down and bridges can collapse under the weight. Because roads are often impassable following a slide, when people are injured, it often costs a great deal to airlift them to safety. Hospital and insurance costs are sure to increase for victims of the mudslide.

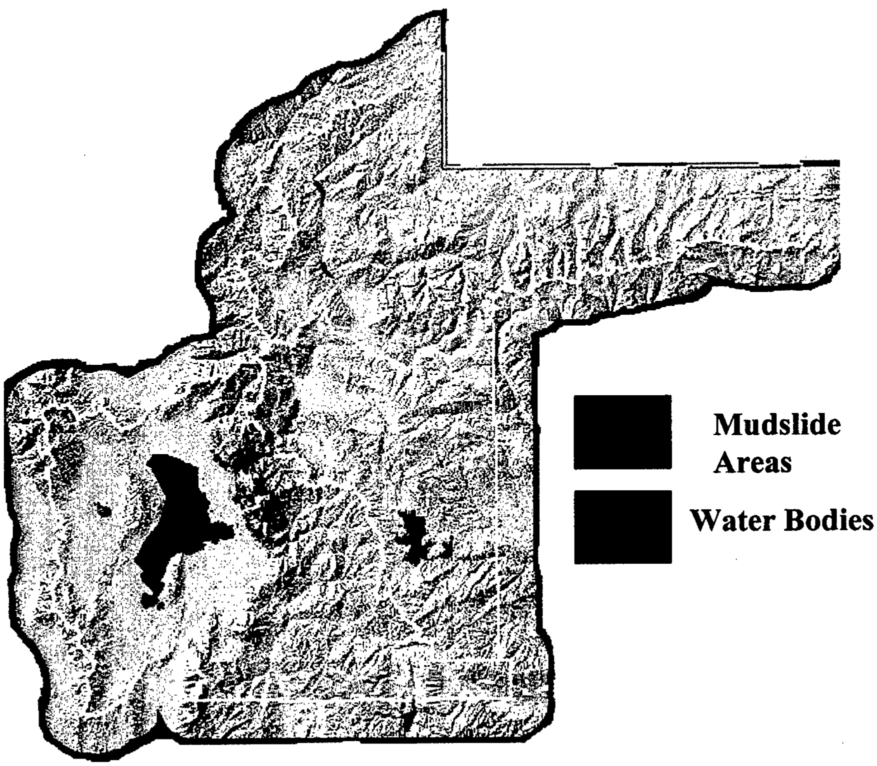

Figure 7. Historic and potential mudslide areas in the study area (in red).

Shrink/Swell Soils

Much of the soil that is present in the MAG region is good for agricultural and building uses. However, there are a few soil types in the area that contain a high percentage of clay. Clay soils are also known as "expansive" soils because of their ability to shrink and

swell. Each year, expansive soils cause more than $3 billion worth of damage to structures and roads in the U.S (Bryant, 1991). The process works slowly (see Figure 8), so the damage is often not as obvious as that associated with other natural disasters. Of all the homes built on expansive soil in the study area, 10 percent of them will undergo significant damage and 60 percent will have minor damage caused by these soils (Bryant, 1991). This part of the model identifies locations in the study area that have high percentages of expansive soils (see Figure 9).

Damage to structures caused by expansive soils includes cracks in the foundation, floors, and walls. Most large buildings built on these types of soils will not receive much damage because the weight of the building will prevent expansion. Insurance costs are largely born by society, as most building owners continue to build on expansive soils. In the study area, many homes have basements, which can be structurally damaged if they are built in areas where expansion and contraction of the surrounding soil occurs. The most effective way to prevent damage caused by expansive soils is to avoid building on them (Bryant, 1991).

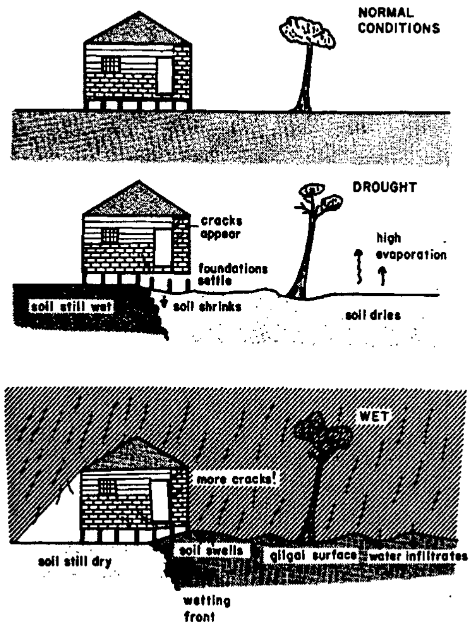

Figure 8. Mechanism of soil expansion and contraction (Bryant, 1991).

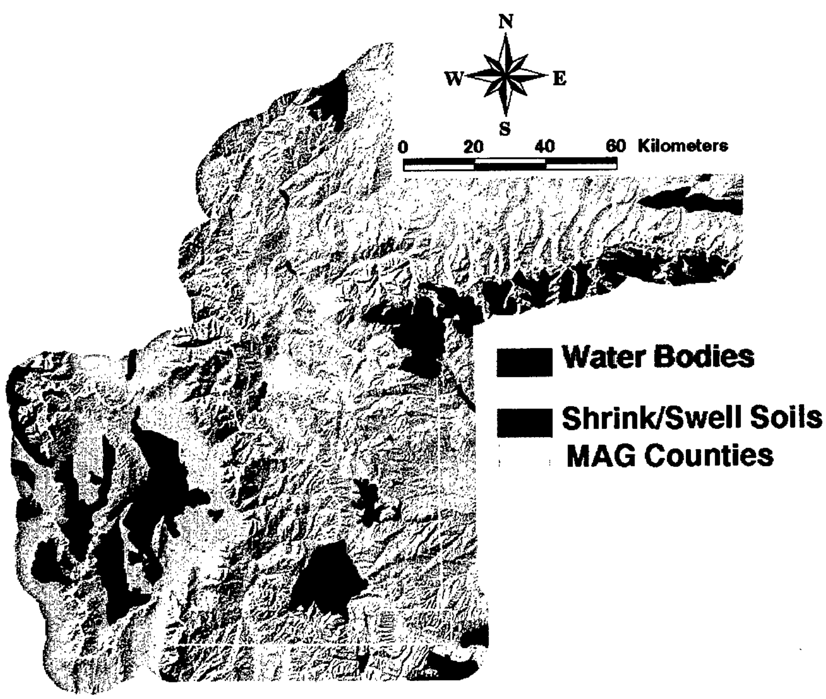

Figure 9. Soils with high shrink/swell capacity (in red).

Shallow Groundwater

When groundwater is close to the surface, it is much more susceptible to contamination from point and non-point sources. As the contaminants leach into the soil, the static charges on the soil particles often retain many of the contaminants. However, if water is present before all the contaminants can be removed by the soil particles, then the water can become polluted (Hecker et al. 1988). The GIS data available described shallow groundwater in the study area in two categories: 3.5 meters below the surface and 10 meters below the surface. In the model, both depths of groundwater were included, with the 3.5 meter depth being weighted higher than the 10 meter depth. The purpose of this part of the model was to identify areas of the region that had shallow groundwater (see Figure 10).

Shallow groundwater can affect groundwater recharge, water quality and quantity, human health, and structural integrity. Groundwater recharge is the replenishment of an aquifer with water from the land surface (Toth et al., 2002). Recharge rate is usually defined in terms of hectare-meter per year. Often this water comes from rain or snow, but may be present in streams, lakes, irrigation return, inter-aquifer flows, and sewers (Toth et al., 2002).

If any of the sources of groundwater recharge are contaminated, then there is a high possibility shallow groundwater will also become contaminated. This is especially true when septic systems are present. Water quality is often poor in shallow groundwater areas that are close to septic systems. Many other point sources were established decades ago, before we understood their potential negative effect on water quality. Unfortunately, these point sources but have been "grandparented" into areas where current regulations

would make them illegal (Toth et al., 2002). Non-point sources are often more widespread, but when taken collectively can still have damaging effects to water quality. Other sources of contamination include small businesses like dry cleaners, automotive repair shops, and restaurants (Toth, 2002).

Water quantity can also be reduced in areas with shallow groundwater. Due to a rapidly increasing population, water is sometimes taken out of underground aquifers more rapidly than recharge can replace it. Sometimes subsidence can result if water is taken out too quickly. This happens when the vapor pressure in an aquifer is reduced and the land above the aquifer begins to sink—sometimes from a few centimeters to several meters (Bryant, 1991). These sinkholes can cause damage to infrastructure like roads, as well as causing damage to commercial buildings, agricultural fields, and homes and reduce aquifer capacity.

Human health can also be affected by shallow groundwater. Since contamination is more likely in these areas, the potential for humans to ingest polluted water is greatly increased. Dysentery, nausea, or other gastro-intestinal diseases can become widespread in areas that have shallow groundwater that has become contaminated by surface sources. These diseases are of special concern during floods, earthquakes, and mudslides when normal drainage systems become less or non-functional.

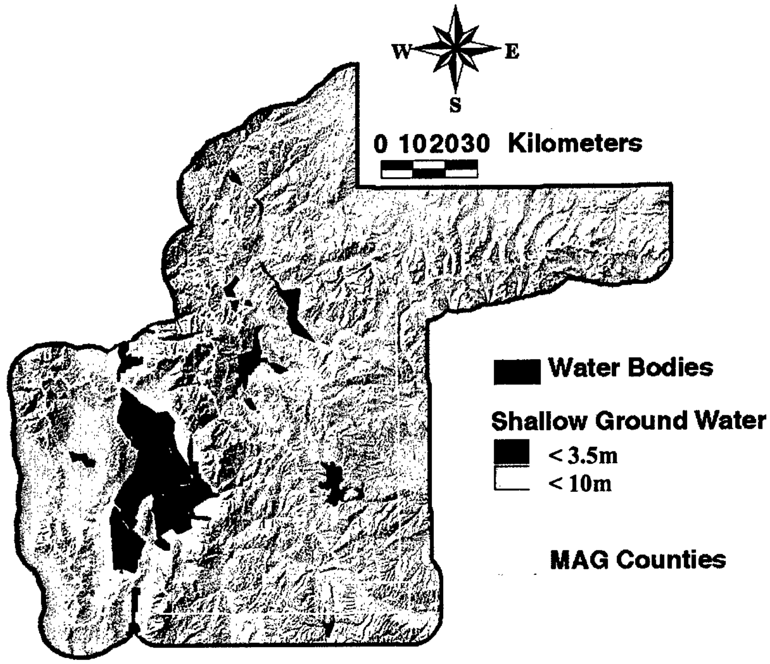

Figure 10. Locations in the study area with groundwater 3.5 meters (red) and 10 meters (pink) below the surface.

Floodplains

No one can predict when a "100 year flood" is going to take place. According to Wijkman and Timberlake (1988), floods are increasing faster than any other natural disaster. Predicting when a flood will occur is difficult, but predicting where it will affect people is not as difficult (Turcotte and Haselton, 1996). In 1993, much of the Mississippi River basin experienced just such a flood (Steinberg, 2000). The levees and other structures designed to keep the water in the riverbanks were not able to prevent the water from flowing over the low-lying fields and towns along the banks. Often, the land in the floodplain is less expensive, so the poor are usually the primary victims of flooding (Wijkman and Timberlake, 1988). In the MAG region, there are also low-lying areas that

are susceptible to flooding, if water levels in lakes and rivers elevate beyond their banks. However, unlike the regional flood that affected the Mississippi Valley in 1993, the floods that will affect the study area are likely to be flash floods, resulting from intense precipitation in a short time (Bryant, 1991).

The purpose of this part of the model is to identify areas of the landscape that lie within floodplains and are hence more susceptible to the damaging effects of flash floods (see Figure 11). One constraint of the GIS data is that only Utah County's floodplain information was available. However, since a majority of the population of the MAG region is located in Utah County, this information, although limited, was acceptable.

Like many of the other landscape attributes that can affect the public, floodplains have the potential to cause impacts to human health, damage to structures and infrastructure, and increased health care costs. Thousands of people perish each year by drowning or other injuries incurred during flooding, and billions of dollars in damage is done to property by floods. Property insurance and special flood insurance premiums rise when a flood occurs, and since it is mainly the poor who live in floodplains, (Steinberg, 2000), this can cause financial difficulty for many families. In 2001, more than $7 billion in damage was caused by floods in the United States (Pielke, 2002). When people become stranded, special rescue personnel must be called in to save them, which is expensive and life threatening.

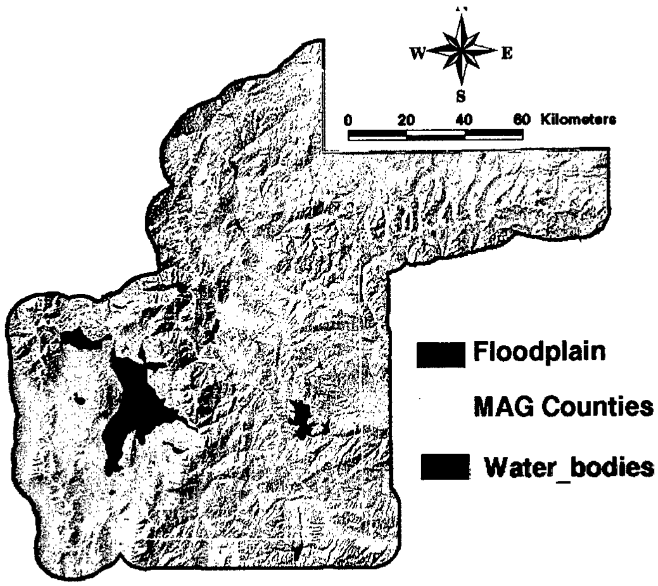

Figure 11. Floodplains in the study area (in red). Only Utah County is represented.

High Fire Risk

After numerous years of drought and fire prevention, many parts of the study area are prime candidates for wildfires (Bryant, 1991). As the population increases, the areas that previously were not inhabited will become more densely populated. Within the study area, one area that is growing in human population is the wildland/urban interface. These areas typically have a high fuel load of woody plants and grasses, both of which ignite and burn easily (Bryant, 1991).

The purpose of this part of the model is to locate those areas of the study area that have high fire risk, based on fuel load, slope, and average annual precipitation. The data was provided by the Utah Department of Forestry, Fire, and State Lands and was produced in 1998 (see Figure 12). Since the data are five years old, the areas indicated as high fire risk may actually be larger today because the study area has been in a drought.

Fires can affect water quality, human health, buildings, and infrastructure, and increase health care costs. When fires burn, they can sometimes degrade the quality of the underlying soil, even to the point it becomes sterile and cannot support vegetation. This can increase erosion, siltation of water sources, and the chance of mudslides. Also, ash that is introduced into riparian areas could degrade water quality and reduce recreation opportunities (Toth et al., 2002).

If particulate matter from fires is ingested into the respiratory tract, it can be dangerous. Small particles can be inhaled and lodged deep within the lungs, where they can remain for longer periods of time (Toth et al, 2002). The particles may affect humans by their inherent toxicity, interfering with normal physiological processes in the lungs, or carrying toxins from other materials into the body.

Buildings and infrastructure like power lines are extremely susceptible to wildfires. In the summer of 2000 there were 1,929 fires and 227,825 acres burned in Utah (Utah Bureau of Land Management, 2003). In 2002, by September 3rd, Utah had lost 261,930 acres to wildfires (National Climatic Data Center, 2002). In almost all these fires, structures were not involved, but the danger to buildings is still high.

Since the Clean Air Act was passed, some counties in Utah have had to increase their vigilance on preventing airborne pollutants. When fires are burning, they release volatile organic compounds into the atmosphere. In addition to increases in direct health care costs, reduced visibility along the Wasatch Front could affect the mental welfare of the people living in this area (Toth, 2002). Maintaining aesthetic qualities has been recognized as increasing human perceptions of well being.

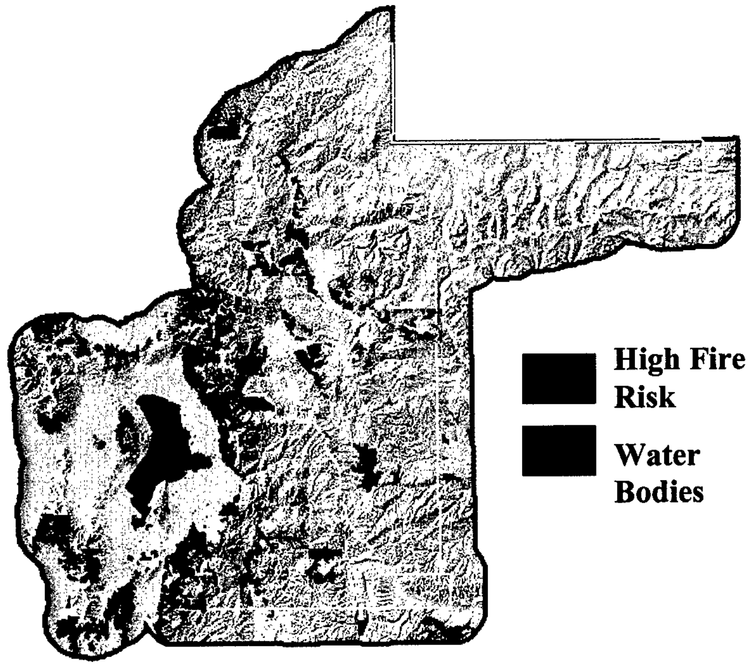

Figure 12. Areas in the study area with high wildfire risk (in red).

Composite Model

When all the different landscape features are layered on each other, many of the individual hazards overlap. A gradient was created to identify areas posing low and high levels of risk (Figure 13). It is this map that will be of the most use to planners as they attempt to influence development. Each area represented in the composite map is potentially dangerous. The areas that are light red present the least hazard and those in dark red are highly hazardous to public health, welfare, and safety. Much of the most dangerous areas are concentrated in the southwest corner of Utah Lake. Unfortunately due to other location features, this area has been mentioned as a potential location for new communities. Planners should take this composite map into consideration when

recommending development in the MAG region—especially in locations that are indicated as high risk areas.

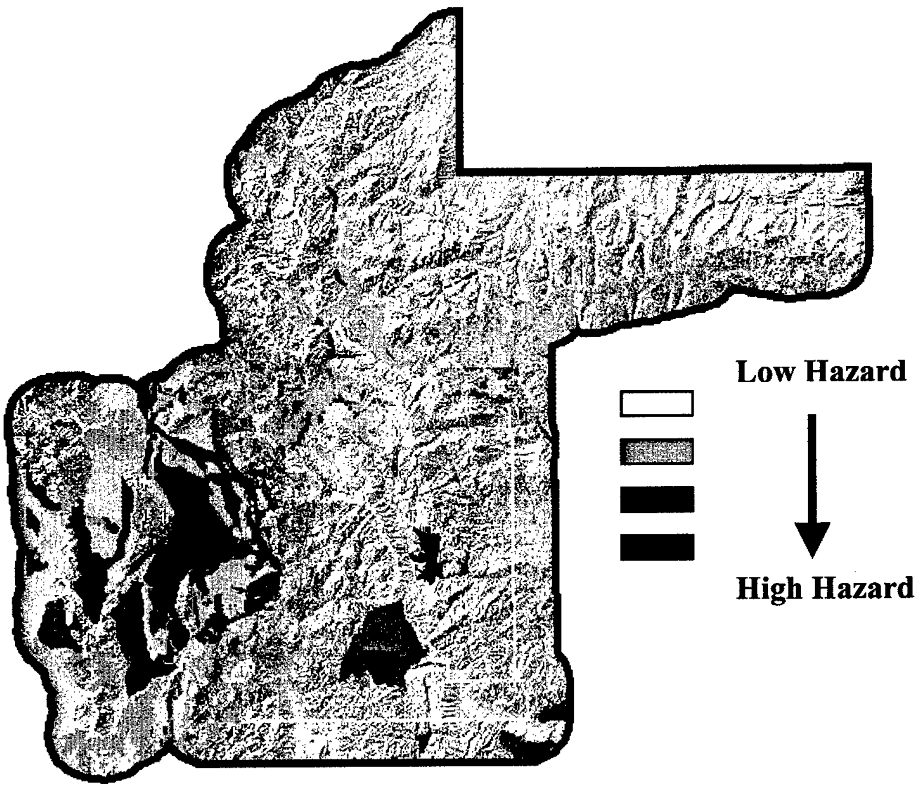

Figure 13. Composite map showing overlap of hazardous landscape features. The dark red areas are highly hazardous.

ALTERNATIVES FOR IMPLEMENTATION

Implementing the necessary policies to mitigate the effects of natural disasters is sometimes difficult. Often implementation is only possible after a disaster has occurred. Public apathy and economic constraints may reduce a planner's ability to plan for natural hazards (Langton and Chapman, 1983). However, when hazard mitigation planning is introduced following a natural disaster, history has shown that casualties in the next disasters are significantly reduced (Lamb, 1991). The key to receiving public support is

in making the public perceive there is a problem. They must be made aware that the risk of death, injury, or loss of property has reached an unacceptable level and they must believe it is possible to successfully mitigate effects of future disasters (Chapman, 1994). One way to implement hazard mitigation plans is to require that areas with high danger be set aside as open space. This prevents development and reduces the chances of loss of life or property (Toth et al., 2002). A summary of open space preservation measures is available in Toth et al. (2002).

If open space designation is not possible, there are other steps that can be taken. A management model for natural hazard mitigation was developed by Chapman (1994). He outlined five analyses that should be undertaken to effectively manage natural hazards. They included event analysis, vulnerability analysis, risk analysis, response analysis, and decision analysis. The figure below is taken from Chapman (1994).

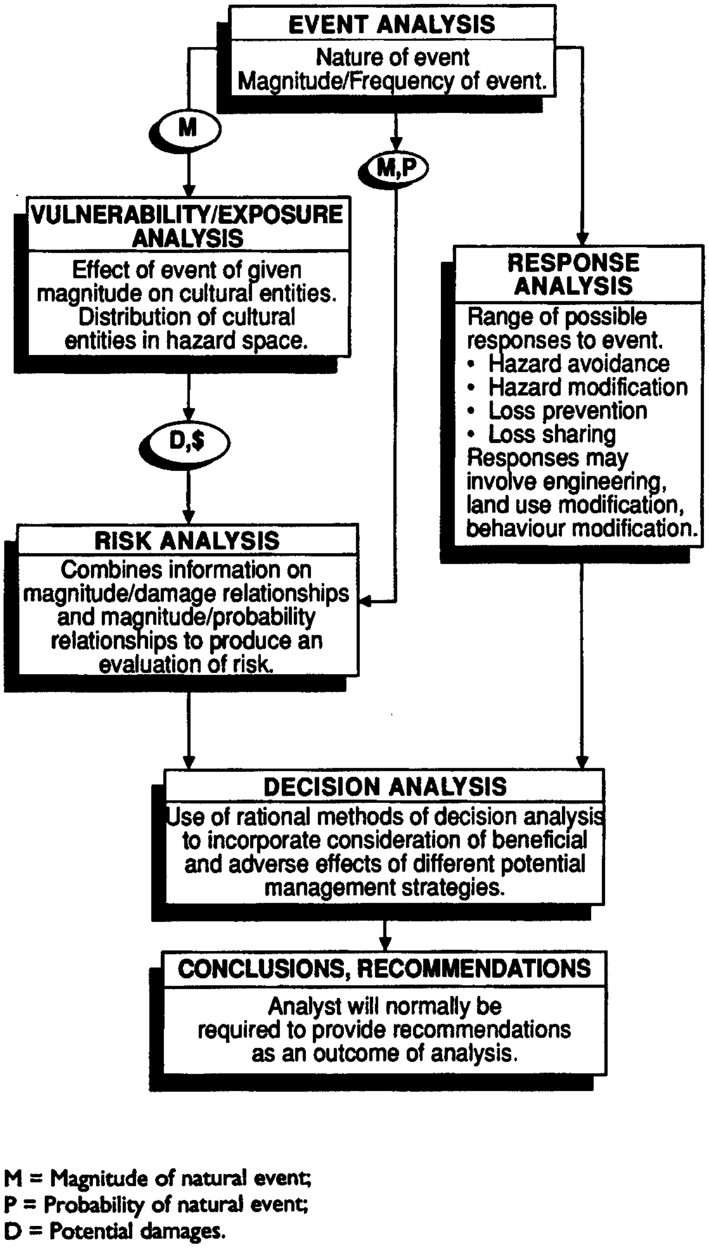

Figure 14. Natural hazard mitigation analysis plan (Chapman, 1994).

Petak and Atkisson (1982) delineated a number of different strategies that state, county, and local governments can take to help mitigate the dangers of natural hazards. The

federal government Disaster Mitigation Act of 2000 provides guidelines to help communities with preparation for natural disasters.

Regardless of how the management plans are implemented, it is important for planners in the United States and the MAG region, to understand the hazards present in nature and to plan for them accordingly. The economic, social, and human health costs of natural disasters outweigh the benefits gained by developing in areas with high risk. The MAG region is an area that represents other rapidly growing areas of the county. While it may not have the same natural hazards as other areas, the public health, welfare, and safety model presented could easily be used in other areas where planners want to emphasize natural disaster mitigation.

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